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Global Links: The Benefits to Domestically-Controlled Plants from Inward Direct Investment–the Role of Vertical Linkages

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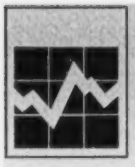

Statistics Canada
Micro-economic Analysis Division

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Alla Lileeva

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Preface

*U*sing data on manufacturing plants operating in Canada for the period from 1981 to 1997, we estimate the effect of changes in the level of foreign control upon labour productivity in domestically-controlled plants. We distinguish between foreign control in own industry of domestically-controlled plants and foreign control in industries linked by their supply or use of intermediate inputs. We find that foreign control increases productivity growth in domestically-controlled plants in a way that is consistent with the transfer of technology from foreign suppliers to domestically-controlled plants. The positive productivity effects of foreign control are more pronounced for those plants that outsource more intermediates, and who purchase science-based intermediate inputs (i.e., electronics, machinery and equipment, and chemicals).

Keywords: foreign control, technology, spillovers

JEL codes: F2, O1; O3

Executive summary

This paper evaluates the effects of inward United States foreign control on the productivity of domestically-controlled plants in Canada over the period from 1980 to 1996. It distinguishes inter-industry "vertical linkages" effects of foreign control from the intra-industry productivity effects. We use Canadian Input-Output tables to construct proxies for foreign control in supplier and customer sectors. Our measures of inter-industry linkages are constructed at the detailed level of 145 manufacturing industries. The focus of the paper is on the technological contents of intermediate goods supplied or used by foreign-controlled producers in the Canadian marketplace, as well as the technological characteristics of suppliers and customers. To deal with a potential endogeneity of the foreign control effects, we apply a double-differencing methodology as well as use alternative instrumental variables strategies.

We find that vertical linkages with foreign-controlled plants are positively related to the productivity growth of domestically-controlled plants. The paper shows that the presence of foreign producers in supplier sectors has a strong positive association with productivity growth in domestically-controlled plants.

We also find that the technological content of linkages is a crucial determinant of productivity gains in domestically-controlled plants. The benefits from foreign control are particularly important for science-based manufacturing industries (e.g., producers of machinery and equipment, electronics and chemicals). Effects from foreign control in high-end manufacturing are strong for all domestically-controlled plants, and especially for those outsourcing from the science-based industries. Furthermore, higher foreign control in science-based supplier industries is strongly associated with increased output and the increased use of manufactured intermediate inputs by domestically-controlled plants. This suggests that the results are driven by technology issues, rather than by competition alone.

Finally, we find that higher competition from foreign-controlled producers is negatively related to productivity growth in domestically-controlled plants in a way that is consistent with market-stealing by foreign-controlled producers. However, these negative own-industry effects are more than offset by the positive inter-industry spillovers.

Chapter 1. Introduction

Recent empirical work points to the importance of international technology transfer as a driver of technological change and productivity growth (Coe and Helpman, 1995; Eaton and Kortum, 1999). Yet there remains significant disagreement about the channels through which technology is transferred across countries and, in particular, about the role played by foreign direct investment. Studies of aggregate productivity growth identify the economically important and positive role played by foreign direct investment, at least for Germany, the United Kingdom and Canada (see Barrell and Pain, 1997; Gera, Gu and Lee, 1999). In contrast, a cross-country study of industry-level productivity growth involving OECD countries found only a limited role for foreign direct investment (Keller, 2001). A prominent study of foreign direct investment spillovers, carried out for the case of Venezuela (Aitken and Harrison, 1999), actually found that a higher presence of foreign-controlled producers in an industry is negatively associated with the productivity of domestically-controlled plants.

New theoretical and empirical work on the effects of foreign direct investment suggests that domestically-controlled plants are more likely to benefit from supplier or customer linkages with foreign-controlled producers, than from intra-industry knowledge spillovers from foreign-controlled competitors. In particular, findings by Blalock and Gertler (2004) for Indonesia and Smarzynska Javorcik (2004) for Lithuania show that having foreign-controlled customers has positive effects on the productivity of indigenous input suppliers.

This paper evaluates the effects of foreign control that arises from inward foreign direct investment on the productivity of domestically-controlled plants in Canada. It distinguishes inter-industry "vertical linkages" effects of foreign control from the intra-industry productivity effects. There are several major differences between this work and earlier research. Firstly, we focus on the technological contents of intermediate goods supplied or used by foreign-controlled producers in the Canadian marketplace, as well as the technological characteristics of suppliers and customers. As there are no data sets available with information on input suppliers and output consumers at the individual firm level, the approach taken by researchers to date is to proxy plant-level linkages by the linkages between industries. However, Statistics Canada's Input-Output tables allow us to define inter-industry linkages at a far more detailed level of disaggregation than has been used in previous studies.[1]

Our measures of linkages are constructed at the level of 145 manufacturing industries. At this level of disaggregation, we find that inter-industry linkages are very important: about 80% of the inputs of a typical manufacturing industry originate from other manufacturing industries. This detailed information is critical for our research because it allows us to

distinguish linkages by their technological content—something that has not been done before. This paper finds the technological content of linkages is a crucial determinant of productivity gains in domestically-controlled plants. In addition, the Canadian Input-Output tables allow us to examine changes in vertical linkages over a very long time span, from 1981 to 1997. It is an important feature of this work, because as many authors have noted, the knowledge spillovers and technology transfer effects of foreign direct investment are likely to gestate over very long periods of time (McAleese and McDonald, 1978; Mansfield and Romeo, 1980).

Secondly, our work differs from earlier empirical research that evaluates various channels through which foreign direct investment impacts plant performance by evaluating the inward foreign direct investment effects for a highly developed, small open economy. The previous literature is primarily limited to developing countries (e.g., Blalock and Gertler, 2004) or economies in transition (e.g., Smarzynska Javorcik, 2004). However, developing countries typically have neither the absorptive capacity nor the domestic linkages to foreign-controlled suppliers and customers. What makes Canada's case even more interesting is its long and extensive exposure to foreign producers, who produce close to 50% of Canadian manufacturing output. The vast majority of inward foreign direct investment is done by affiliates of the United States multinationals, that is, by highly technologically advanced parents. In his study of international R&D spillovers, Keller (2001) asserts that Canada's close economic ties with the United States are responsible for disproportionately high benefits that Canada receives from the R&D done by OECD countries. He estimates that 70% of the international technology diffusion into Canada originates in the United States. Further, a recent survey of Canadian firms shows that foreign-controlled firms actually establish inter-firm supplier and customer linkages with Canadian enterprises. The survey also suggests that the vertical-linkage and knowledge-spillover channels of technology transfer are both likely to be important. According to the survey, 46% of firms cited customers as an important source of innovation, 28% of firms cited suppliers, and 28% cited competitors (Baldwin and Peters, 2001).

Another contribution of our paper is its treatment of endogeneity of foreign direct investment. While all researchers acknowledge that estimates of industry-level foreign direct investment effects are likely to be endogenous, our paper explicitly deals with endogeneity by applying a double-differencing methodology and by using alternative instrumental variables strategies. To our knowledge, this is the first time that the endogeneity of industry-level foreign direct investment effects has been explicitly addressed.

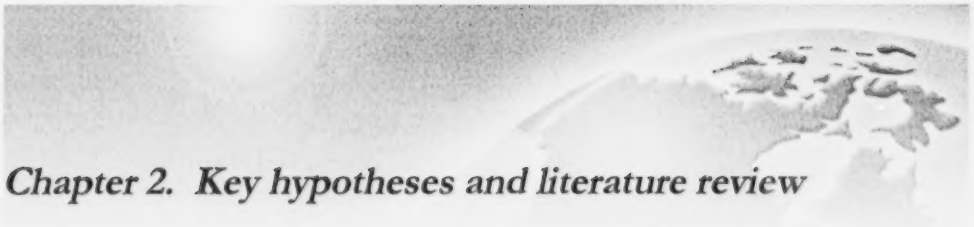
Our major finding is that vertical linkages with foreign-controlled plants are positively related to the productivity growth of domestically-controlled plants. The paper shows that the presence of foreign producers in supplier sectors has a strong positive association with productivity growth in domestically-controlled plants. The benefits from foreign direct investment are particularly important for science-based manufacturing industries (e.g., producers of machinery and equipment, electronics and chemicals). Effects from foreign direct investment in high-end manufacturing are strong for all domestically-controlled plants, and especially for those outsourcing from the science-based industries. Furthermore, higher

foreign direct investment in science-based supplier industries is strongly associated with increased output and the increased use of manufactured intermediate inputs by domestically-controlled plants. These observations make it clear that the results are driven by technology issues, rather than by competition alone. Higher competition from foreign-controlled producers is, in fact, negatively related to productivity growth in domestically-controlled plants in a way that is consistent with market-stealing by foreign-controlled producers. However, these negative own-industry effects are more than offset by the positive inter-industry spillovers.

Overall, our evidence is consistent with the hypothesis of technology transfer through vertical linkages with foreign-controlled plants. Most importantly, we find that not only does the extent of linkages matter, but that the technological content of these linkages matters a great deal.

Endnotes

1. In particular, Smarzynska Javorcik (2004) used a 5-year long panel for Lithuania with inter-industry linkages defined at 20 NACE (Statistical Classification of Economic Activities within the European Communities) 2-digit industries.



Chapter 2. Key hypotheses and literature review

The presence of highly advanced foreign producers in the Canadian market may increase competition for, as well as promote the diffusion of foreign technologies to domestically-controlled plants. Such technology transfer can occur either as a result of knowledge spillovers or as a result of vertical linkages between foreign-controlled and domestically-controlled plants. When a foreign-controlled plant enters the Canadian market, it has an opportunity to establish vertical linkages with domestic producers in related industries. Possible interactions between domestically-controlled and foreign-controlled plants are illustrated in Figure 1.

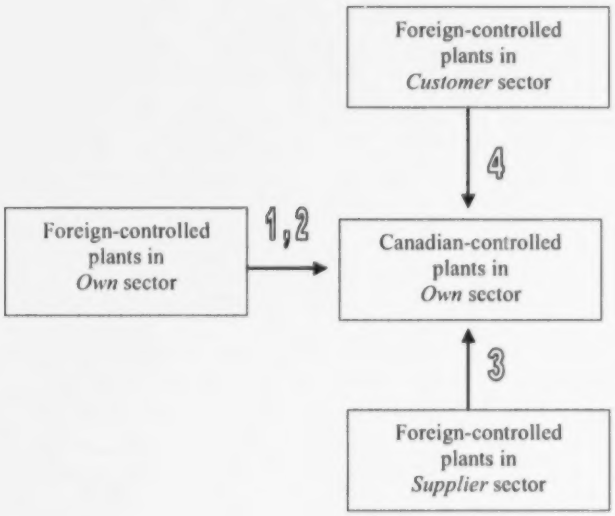
Knowledge spillovers and competition

The *knowledge spillovers hypothesis* begins with the observation that knowledge has a public goods component. Since the pool of knowledge is, in part, a public good, domestically-controlled plants may be able to exploit innovations produced by foreign-controlled plants without incurring the full costs of development. Relatively more technologically advanced foreign-controlled plants create opportunities for learning (Figure 1, arrow 1) while intensifying competition (Figure 1, arrow 2) for domestically-controlled plants in the same industry. To date, this has been the most extensive area of research into foreign direct investment spillovers, based on evidence from case studies, and industry-level and micro-level analyses.

In Canada, Gera, Gu and Lee (1999) used disaggregated manufacturing data (13 industries) for the period from 1973 to 1992 to determine that an increase in the stock of foreign direct investment led to lower production costs in a number of industries, and as well contributed significantly to their total factor productivity (TFP) growth. However, the authors cannot assess whether the increase occurred within the foreign-controlled sector of the economy, as a result of market share reallocation towards more productive plants; or whether positive effects from the presence of multinational plants instead stimulated productivity growth within the domestically-controlled plants. It must be noted that when exploring spillovers, one wants to look specifically at the change of the growth of individual plants using micro data.

Researchers who employ micro data to test for foreign direct investment spillovers get various answers. Aitken and Harrison (1999) found that an increase in foreign production led to a decline in productivity in Venezuelan plants. Muendler (2002) found that the cumulative stock of foreign direct investment is positively related to productivity growth of

Figure 1 Linkages between domestically-controlled and foreign-controlled plants



Source: Statistics Canada.

Brazilian plants, but the effect on productivity is negligible, in particular when compared to the impact of trade. He also found that the flow of foreign direct investment is negatively related to productivity growth. Blalock and Gertler (2004) found no effect on productivity of domestically-controlled plants in Indonesia from an increase in the sectoral share of foreign output. Similarly, Smarzynska Javorcik (2004) found no same sector foreign direct investment effect in Lithuania. On the positive side, Haskel, Pereira and Slaughter (2002) found that an increase in foreign presence in an industry has a positive effect on the TFP of domestically-controlled plants in the United Kingdom. However, the magnitude of the effect is fairly small: a 1-percentage point increase in the foreign share of output raises the TFP by 0.05%. Keller and Yeaple (2004) also found positive spillovers from foreign-controlled producers in the United States.

There are several explanations for these typically modest findings of spillover effects from foreign-controlled plants. First, as Aitken and Harrison (1999) noticed, foreign direct investment may have a strong pro-competitive (or market-stealing) effect on host-country plants in the same sector. Second, a lack of absorptive capacity in developing countries may prevent plants from putting the knowledge gained from foreign-controlled producers into practice. Third, and in keeping with the internalization argument of foreign direct investment which postulates that foreign direct investment occurs to protect a firm from competitors in the host market, the technological advantages of multinational plants do not result in spillover benefits for domestically-controlled plants.[2]

Technology transfer through vertical linkages

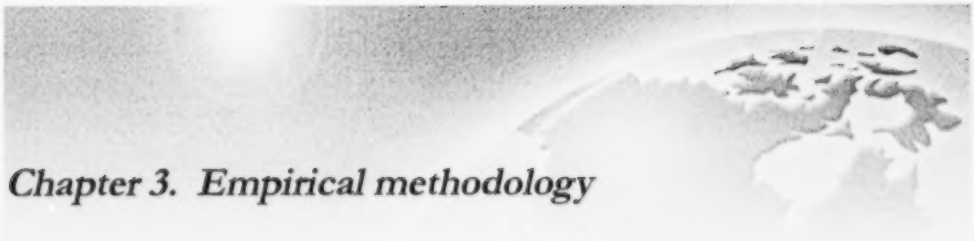
On the other hand, the *vertical linkages hypothesis* is based on the idea that foreign-controlled affiliates do establish vertical linkages with host-country plants and that these linkages facilitate the transfer of new technologies. First, blueprints can be embodied in inputs that are produced by a foreign-controlled plant and used by a host-country plant (Figure 1, arrow 3, a case of "Sophisticated Seller"). Alternatively, a foreign-controlled plant may provide a host-country plant with blueprints necessary for production of intermediate inputs (Figure 1, arrow 4, a case of "Sophisticated Buyer"). To illustrate the latter channel, Rodriguez-Clare (1996) sets up a theoretical model, in which multinationals benefit a host country by expanding the set of intermediate inputs available there.

The extent of these vertical linkages most probably depends on host country features. In Canada, according to Baldwin and Hanel (2000), out of the surveyed foreign-controlled firms involved in research collaboration, 29% report collaborative R&D activities with Canadian customers, and 23% with Canadian suppliers, while only 1% collaborates with Canadian competitors. These numbers suggest that home-foreign collaboration in Canada is quite likely. They also suggest that the benefits from superior R&D capabilities of foreign-controlled firms are more likely to be accrued by domestically-controlled plants when they are integrated into supply and demand chains with the foreign firms, rather than being pure competitors.

The literature on technology transfer through vertical linkages is small, and includes the previously mentioned studies by Blalock and Gertler (2004) who found that linkages with foreign customers had a positive effect on the productivity of indigenous plants in Indonesia, and by Smarzynska Javorcik (2004) who similarly found a positive effect from foreign-controlled customers on the productivity of plants in Lithuania. Chung (1999), using industry-level data, found that an increase in customer foreign direct investment led to a fall in the productivity of United States industries. On the other hand, Chung, Mitchell and Yeung (2003) found that a higher presence of Japanese producers increased overall productivity of the United States auto-parts suppliers, but they attributed this to increased competition for contracts, rather than knowledge spillovers. Harris and Robinson (2004) use micro data and evaluate all three channels for a number of manufacturing industries in the United Kingdom. They conclude that spillovers may be positive or negative, and "there is no clear pattern in terms of which industries experience spillovers, the extent of these (...), and the balance between positive and negative spillovers."

Endnotes

2. For example, out of the foreign-controlled firms in Canada involved in collaborative research efforts, only 1% are reported as having Canadian competitors as R&D partners, while 43% report Canadian universities and 59% report foreign affiliates as their research partners (Baldwin and Hanel, 2000).



Chapter 3. Empirical methodology

Following the approach used in the earlier literature, we begin our analysis by estimating the relationship

$$\pi_{p,i,t} = f(FDI_{i,t}^{OWN}, FDI_{i,t}^{SUP}, FDI_{i,t}^{CUST}, X_{p,i,t}, Y_{i,t}) \qquad (1)$$

where $\pi_{p,i,t}$ is the productivity of plant p in industry i at time t, and $FDI_{i,t}^{OWN}$, $FDI_{i,t}^{SUP}$, and $FDI_{i,t}^{CUST}$ are measures of FDI in own, supplier and customer sectors respectively, is a $X_{p,i,t}$ vector of plant characteristics and $Y_{i,t}$ is a vector of industry characteristics. Note that in this paper the term "FDI" refers to the share of manufacturing output in foreign-controlled companies located in Canada (a stock measure), rather than to flows of investment from abroad.[3] Same sector FDI captures the competition and knowledge spillover effects of foreign direct investment (arrows 1 and 2 in Figure 1 respectively), while foreign direct investment in supplier and customer sectors captures the vertical linkages effects (arrows 3 and 4 in Figure 1 respectively).

Let i index the own industry of a domestically-controlled plant. The share of production by the foreign affiliates in industry i at time t is given by:

$$FDI_{i,t}^{OWN} = \frac{Q_{i,t}^{f}}{Q_{i,t}^{f} + Q_{i,t}^{h}} \qquad (2)$$

where $Q_{i,t}^{f}$ and $Q_{i,t}^{h}$ is output produced by foreign-controlled plants and domestically-controlled plants in industry i at time t. We construct the supplier and customer inter-industry linkages between industry i and industry j using the data from the input-output tables as:

$$CUST_{i,j,t} = \frac{x_{i,j,t}}{\sum_j x_{i,j,t}}, \quad SUP_{i,j,t} = \frac{x_{j,i,t}}{\sum_j x_{j,i,t}}, \quad \sum_j CUST_{i,j,t} = 1, \quad \sum_j SUP_{i,j,t} = 1 \qquad (3)$$

where x represents intermediate inputs, and the first and the second indices refer to producer and user industries respectively. $CUST_{i,j,t}$ gives the share of inputs produced by industry i

that are used by industry *j*. $SUP_{i,j,t}$ gives the share of industry *i*'s input purchases that are sourced from industry *j*. Linkage-weighted FDI in supplier and customer sectors are given by:

$$FDI_{i,t}^{CUST} = \sum_j CUST_{i,j,t} FDI_{j,t}^{OWN}, \quad FDI_{i,t}^{SUP} = \sum_j SUP_{i,j,t} FDI_{j,t}^{OWN} \qquad (4), (5)$$

where *j* and *i* index industries and *t* indexes time. $FDI_{i,t}^{CUST}$ and $FDI_{i,t}^{SUP}$ may increase for two reasons: an increase in inter-industry linkages, and/or an increase in levels of FDI in linked industries. Note that the above variables are constructed using only the aggregate industry-level data and contain no plant-level information. This is a standard approach in the literature, because the manufacturers' surveys *never* collect data on inter-firm purchases. As mentioned, we are able to improve on the previous studies by using a manufacturing database that is disaggregated to 145 industries, as well as account for changes in inter-industry linkages over a longer period of 16 years.

Let the change in any variable *Z* from time *t-s* to *t* be defined as:

$$\Delta_s Z_t = (Z_t - Z_{t-s})/s \qquad (6)$$

The estimating equation is:

$$\begin{aligned} \Delta_s \pi_{p,i,t} &= \alpha_1 + \alpha^{OWN} \Delta_s FDI_{i,t}^{OWN} + \alpha^{SUP} \Delta_s FDI_{i,t}^{SUP} \\ &+ \alpha^{CUST} \Delta_s FDI_{i,t}^{CUST} + \alpha_5 X_{p,i,t} + \alpha_6 Y_{i,t} + \alpha_{p,i} + \alpha_t + \varepsilon_{k,i,t}. \end{aligned} \qquad (7)$$

In equation (7) *p* indexes plants, *i* indexes industries, *t* indexes periods and *s* is the length of the period *t*. Productivity growth $\Delta_s \pi_{p,i,t}$ is given by the change in the log of labour productivity.[4] $X_{p,i,t}$ is a vector of plant characteristics and $Y_{i,t}$ is a vector of industry characteristics. Equation (7) also controls for period-specific and plant-specific fixed effects in productivity growth. This double-differencing methodology allows us to effectively control for a potential endogeneity of FDI in the productivity equation, which will be discussed below.

The coefficients α^{OWN}, α^{SUP} and α^{CUST} capture the effects of changes in same sector foreign control and changes in foreign control in customer and supplier sectors on the growth of labour productivity in domestically-controlled plants. In terms of Figure 1, α^{OWN} captures both channels 1 and 2, α^{SUP} captures channel 3, and α^{CUST} captures channel 4. Since it may take a long time before domestically-controlled plants assimilate external benefits, equation (7) is estimated with *s* set to eight years to capture the long-run effects of foreign direct investment. Another advantage of using the 8-year growth panel is that the periods from 1981 to 1989 and from 1989 to 1997 are closely matched in terms of business cycle fluctuations.

Endnotes

3. For overview of alternative measures of foreign investment in Canada, see Baldwin and Gellatly (2005).
4. Ideally, one would like to use the TFP measures with all proper corrections. However, the database does not contain information on capital stock or investment, so that labour productivity is the only measure of productivity available.

Chapter 4. Data

Manufacturing foreign control in Canada

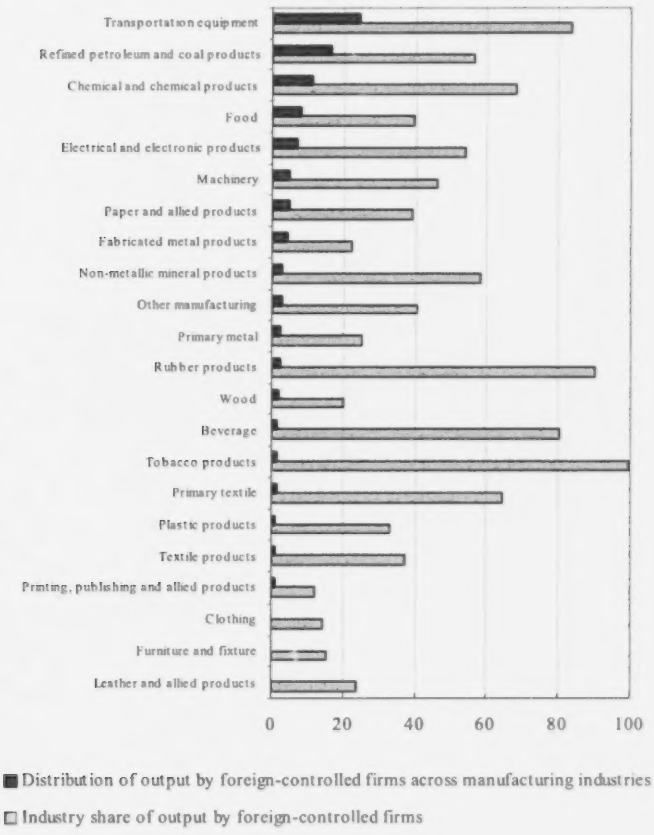
Foreign-controlled producers account for over 50% of Canadian manufacturing output, and this ratio has remained relatively stable over the last 25 years. The majority of output is produced by affiliates of the United States multinationals, who account for over 80% of output produced by foreign-controlled firms in Canada. The majority of foreign control occurs in the 'Transportation equipment' sector, followed by 'Petroleum', 'Chemicals' and 'Food' sectors (Figure 2, black bars). Still, foreign-controlled producers have a significant presence in almost all of the manufacturing industries. Indeed, all of the 22 manufacturing industries (SIC 2-digit level of aggregation) have at least 10% of their output, and 8 industries have over 50% of their output produced by foreign-controlled firms (Figure 2, white bars).

Foreign-controlled firms are not only widely present in Canada, but they also differ noticeably from their domestically-controlled counterparts, even within the same sector. In particular, recent research on foreign-controlled multinationals in Canada consistently found that foreign-controlled plants are more productive than domestically-controlled plants (Baldwin and Gu, 2002). Foreign-controlled plants in Canada are also more likely to perform R&D and introduce product and process innovations (Baldwin and Hanel, 2000), train employees (Baldwin, Gray and Johnson, 1996) and adopt advanced manufacturing technologies (Baldwin, Rama and Sabourin 1999). Therefore, we expect that the productivity of domestically-controlled firms would benefit from foreign competition and/or partnerships involving foreign-controlled firms.

Data description

The plant level data come from Statistics Canada's Annual Survey of Manufactures (ASM), which is a longitudinal database of Canadian manufacturing plants. We are interested in studying the productivity growth *within* domestically-controlled plants, so our analysis is carried out for a balanced panel of 8,088 Canadian-controlled plants that stayed in the market over the period 1981 to 1997.[5] A plant is deemed foreign-controlled if more than 50% of its corporation's voting rights are known to be held outside of Canada or are held by one or more Canadian corporations that are foreign-controlled.[6] The paper focuses on the effects of the United States-controlled producers operating in the Canadian market. The industry-level foreign production was constructed by aggregating the value of shipments of plants that belong to the United States-controlled firms in a given year. Data on value added, employment, value of shipments, intermediate inputs and foreign ownership all come from the Annual Survey of Manufactures database. Table 1 provides sample statistics on the domestically-controlled plants.

Figure 2 Output by foreign-controlled plants, 1997, SIC 2-digit industries



Source: 1997 Annual Survey of Manufactures, Statistics Canada.

Industry-level import and export data and price deflators come from a database previously constructed and described in Trefler (2004). Statistics Canada provided industry-level capital stock. All industry-level variables are aggregated to the level associated with the Statistics Canada Input-Output classification (145 manufacturing industries). The only exception is industry-level capital stock, which is available solely at a slightly higher level of aggregation.

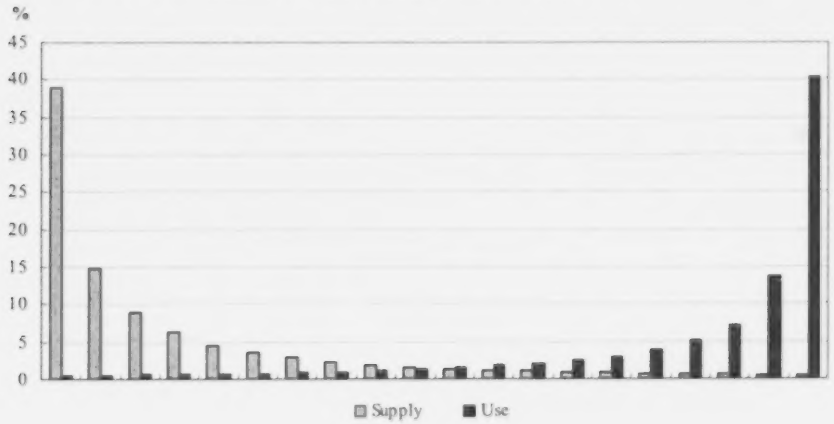
Inter-industry linkages were constructed using the data from Statistics Canada's Input-Output tables for years 1981 to 1997. Figure 3 plots the average percentage of intermediate inputs, outsourced by major customers, or supplied by major suppliers. Around 40% of manufactured inputs are outsourced from one single most important supplier industry or are shipped to one single most important customer industry. Industries ranked 20 or higher, on average, buy or supply less than 1% of their intermediate inputs from or to another industry. Table 2 provides statistics regarding the measures of inter-industry linkages. The average share of inputs produced by the own industry and used by the own industry in total manufactured inputs is 20%. For a median industry, the first, second and third most important buyers/

Table 1 Sample statistics				
Name	Mean	Standard deviation	Minimum	Maximum
Δ Log labour productivity	0.004	0.063	-0.513	0.836
ΔFDI^{OWN}	-0.003	0.009	-0.105	0.055
ΔFDI^{SUP}	-0.001	0.004	-0.024	0.030
ΔFDI^{CUST}	0.001	0.004	-0.023	0.028
Δ Change in exports	0.113	0.049	-0.271	0.271
Δ Change in imports	0.000	0.045	-0.386	0.404
Δ Change in industry capital-labour ratio	0.005	0.015	-0.055	0.099
Initial log labour productivity	10.61	0.305	3.758	13.97
Initial log employment	3.085	0.024	-0.055	0.099

Notes: Pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods, N=16,176. All changes are annual changes. FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Annual Survey of Manufactures, Statistics Canada.

suppliers account for almost 50% of flows of intermediates. These numbers indicate that, on average, industries have highly specialized links. This underscores the importance of using detailed industry-level input-output data to measure FDI in linked industries, since at a high level of aggregation most linkages would originate within a domestically-controlled plant's *own* industry. Table 3 contains cross-industry correlations between the FDI^{OWN} and FDI^{CUST} or FDI^{SUP}. A significantly high and positive correlation implies that sectors with a high share of production from foreign-controlled plants are more likely to have supplier and customer industries that also exhibit high shares of foreign production.

Figure 3 Distribution of inputs supply and use, first 20 related industries



Note: Figure 3 plots the average percentage of intermediate inputs, outsourced by customer, or supplied by supplier industries, ranked in the order of their importance, for the first 20 most important buyers and suppliers.
Source: Input-Output tables, Statistics Canada.

Table 2 Inputs from/to closely related industries (in percentage)				
	First most important supplier as percentage of all supplied inputs	First most important buyer as percentage of all used inputs	Own sector supply as percentage of all supplied inputs	Own sector use as percentage of all used inputs
Mean	39	40	19	20
Standard deviation	19	24	22	24
Minimum	10	6	0	0
Maximum	89	93	89	93

Moments of distribution of suppliers across industries (percentage of intermediate input supplies to external industries)			
	10%	Median	90%
First most important supplier	13	25	50
First and second most important suppliers	22	39	65
First, second and third most important suppliers	29	48	72

Moments of distribution of buyers across industries (percentage of intermediate input supplies to external industries)			
	10%	Median	90%
First most important buyer	12	26	76
First and second most important buyers	21	40	85
First, second and third most important buyers	27	50	88

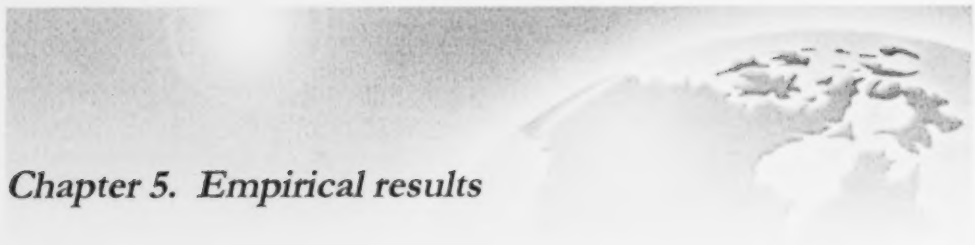
Note: External refers to all industries, excluding own industry of a plant.
Source: Input-Output tables, Statistics Canada.

Table 3 Correlation between foreign control in the own sector and linked industries			
Correlation	1981	1989	1997
FDI^{OWN} and FDI^{CUST}	0.46	0.42	0.35
(Probability)	*(<0.0001)*	*(<0.0001)*	*(0.0002)*
FDI^{OWN} and FDI^{SUP}	0.36	0.27	0.23
(Probability)	*(<0.0001)*	*(0.0011)*	*(0.005)*
FDI^{CUST} and FDI^{SUP}	0.19	0.24	0.24
(Probability)	*(0.021)*	*(0.002)*	*(0.003)*
N	145	145	145

Notes: FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Annual Survey of Manufactures and Input-Output tables, Statistics Canada.

Endnotes

5. The plants in the auto industry are excluded from the sample, because Canadian auto parts producers either belong to Canadian-controlled multinationals or are already integrated into North American auto manufactures networks since the Canada-United States Auto Pact. Therefore, we do not expect domestically-controlled plants in these industries to be affected by the presence of the United States producers in Canadian market. In particular, Baldwin and Gu (2005) found that Canadian-controlled multinationals operating in the Canadian market are as productive as the United States-controlled multinationals operating in the Canadian market.
6. The corporation can be assigned Canadian ownership if the majority of ownership is foreign, but the voting rights held in Canada constitute the single largest group reported by any country.



Chapter 5. Empirical results

Plant and industry controls

The estimates of equation (7) are presented in Table 4. Before turning to a discussion of the main results, we briefly discuss the effects of plant and industry controls on the labour productivity growth of domestically-controlled plants. Since plants are highly heterogeneous, the basic specification includes plant fixed effects in order to control for unobservable plant characteristics that can provide productivity growth advantages to certain plants. We also control for time-variant plant characteristics such as plant size and the level of labour productivity at the beginning of the period. The industry-level controls include capital stock per worker and changes in imports and exports. The former controls for industry-specific trends in labour productivity. The interdependence between FDI, exports and imports is well established in literature (e.g., Brainard, 1997; Blonigen, 2001). Trade exposure, in turn, may have an effect on the productivity growth of plants (e.g., Trefler, 2004). Consequently, we include trade variables to control for the possibility of spurious correlation between FDI and productivity. One should note that while exports and imports in the aggregate productivity equation are generally viewed as endogenous, the endogeneity is unlikely to be an issue if the specification controls for plant and industry fixed effects in productivity growth (Trefler, 2004).

Table 4 Productivity growth in Canadian plants and United States foreign control

Specification	Plant FE	
	β	t
Industry controls		
ΔFDI^{OWN}	-0.128	*-2.33*
ΔFDI^{SUP}	0.625	*4.85*
ΔFDI^{CUST}	-0.110	*-0.96*
ΔExports	0.028	*3.11*
ΔImports	-0.015	*-1.40*
ΔCapital stock	-0.046	*-1.33*
Plant controls		
Labour productivity	-0.164	*-117.1*
Employment	0.008	*6.43*
Adjusted R^2	0.64	...

... not applicable

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods, N=16,167. Estimates are based upon equation (7). Same plant and industry controls are used in all productivity growth regressions. All regressions control for plant and year fixed effects.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

Table 4 gives estimates of equation (7) when the period length s is set at eight years. It shows that larger plants are more likely to experience growth in their productivity, and plants with initially higher levels of productivity are less likely to grow.[7] Higher industry exports are positively associated with growth. Both higher imports and higher capital stock per worker have negative signs in the productivity equation, but these results are not statistically significant.[8] Table A1 in Appendix provides estimates for alternative specifications that omit capital stock, imports and exports. The key findings of the paper are not sensitive to these changes.

Foreign control effects

To contrast our findings with the body of research on the effects of FDI, equation (7) is estimated using the common measure of foreign presence in own industry of domestically-controlled plants, $FDI_{i,t}^{OWN}$ (Table 5). The FDI effect is found to be negative but is not statistically different from zero: the coefficient on $FDI_{i,t}^{OWN}$ is -0.063 (t=-1.24).[9] The following row in Table 5 gives estimates of equation (7) accounting for changes in FDI in own, supplier and customer industries. Own industry FDI has a negative effect on the productivity growth of domestically-controlled plants. The estimates suggest that a one percent increase in the share of foreign production will reduce the productivity growth of domestically-controlled plants by 0.128 percentage points (t=-2.33). This negative result is similar to that found by Aitken and Harrison (1999) for Venezuela, except they found an even larger 0.267 percentage point productivity growth reduction.

We find the effect of FDI in supplier sectors to be positive and highly significant. A one percentage point change in the FDI in supplier sectors increases annual productivity growth by 0.625% (t = 4.85). FDI in customer sectors has no significant effect on productivity. Evaluated at the standard deviations of variables, own sector FDI reduces annual labour productivity growth by 0.12%, while at the same time FDI in supplier sectors raises annual productivity growth by 0.25% in all industries. The clear contrast between the first and the second rows of Table 5 highlights the fact that researchers who overlook FDI in customer and supplier industries may miss an important piece of the overall picture regarding the effects of FDI on the domestic economy. Furthermore, because $FDI_{i,t}^{OWN}$ in the absence of linkage-adjusted FDI variables, captures both competition/spillover effects (which are estimated to be negative) and vertical-linkages effects (which are estimated to be positive), the coefficient on $FDI_{i,t}^{OWN}$ is likely to underestimate the negative effect of foreign competition on domestically-controlled producers.

Researchers generally acknowledge the likelihood that estimates of industry-level foreign direct investment effects could be endogenous. For example, multinational plants may chose to invest in industries with higher productivity growth. Or conversely, foreign-controlled producers may take advantage of the relatively low competitiveness of domestically-controlled plants. In addition, foreign-controlled multinationals may locate in Canada, knowing that potential suppliers or buyers of their products are experiencing high productivity growth. Hence, the estimates of equation (7) may actually overestimate or underestimate the extent of benefits arising from foreign direct investment. Consequently, we want to investigate this issue more fully.

Table 5 Productivity growth and United States foreign control in major customer and supplier industries

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2	Over-identifying restrictions test		Hausman test	
	β	*t*	β	*t*	β	*t*		Test statistics	*Probability*	Test statistics	*Probability*
Plant FE											
FDI in all industries	-0.063	*-1.24*	...	...	...	...	0.64	...	...	...	...
FDI in all industries	-0.128	*-2.33*	0.625	*4.85*	-0.110	*-0.96*	0.64	...	...	...	...
FDI in major supplier and customer industries	-0.159	*-2.93*	0.713	*5.20*	0.119	*0.87*	0.64	...	...	...	...
Plant FE, IV I[1]											
FDI in all industries	-0.221	*-2.35*	0.718	*3.25*	-0.573	*-2.38*	0.64	4.25	*0.35*	5.94	*0.82*
FDI in major supplier and customer industries	-0.256	*-2.68*	0.937	*3.04*	-0.374	*-1.22*	0.64	2.81	*0.17*	6.67	*0.75*
Plant FE, IV II[2]											
FDI in all industries	-0.591	*-1.85*	2.039	*4.16*	*0.371*	*0.35*	0.63	8.14	*0.98*	12.19	*0.27*
FDI in major supplier and customer industries	-0.575	*-1.51*	3.334	*3.98*	0.927	*0.45*	0.63	11.47	*0.99*	12.04	*0.28*

... not applicable

1. Instruments, IV I: lagged changes in FDI in own, supplier and customer sectors, their squares and their products (nine instruments).
2. Instruments, IV II: Canadian and U.S. tax rates, U.S. tariff against Canada, U.S. tariff against the rest of the world and sales by affiliates of U.S. corporations in the rest of the world (five instruments).

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods, N=16,176. Estimates are based upon equation (7). Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects. Major customer industries are defined as the top customer industries, who cumulatively outsource 50% of the own industry's output of manufactured intermediate inputs. Major customer industries are defined as top supplier industries, who cumulatively supply the first 50% of the own industry's manufactured intermediate inputs.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

In general, our specification should control for plant- and industry-level fixed effects, in a way that adequately deals with endogeneity. However, industry-level explanatory variables, which are endogenous in industry-level growth regressions, are often found to be exogenous in regressions that control for plants' fixed effects in productivity growth (examples can be found in Trefler (2004)). The reason is that foreign producers make their decisions to invest in Canada based on levels or growth trends of industry-level productivity, rather than on deviations of plant productivity growth from plant-specific trend. Furthermore, a lack of valid instruments for foreign direct investment flows often forces researchers to disregard a potential endogeneity problem.

To more fully and explicitly address the endogeneity issue, we therefore estimate equation (7) by employing two alternative instrumental variable strategies. In IV (I), foreign control in own, supplier and customer sectors are instrumented with lagged values of foreign control in the three sectors, their squares and their cross-products. In IV (II), the set of instruments consists of changes in Canadian and United States tax rates,[10] United States foreign control in the rest of the world,[11] changes in the United States tariff against Canada, and changes in the United States tariff against the rest of the world.

The first stage regression coefficients are reported in Appendix Tables A2 and A3. The first stage estimates for IV(I) show that foreign control in own sector, supplier and customer sectors follow mean reversion: higher levels of foreign control are associated with less growth in the following period. Also, in vertically-integrated sectors, higher sectoral foreign control is associated with a subsequent increase in foreign presence in vertically-integrated

sectors. The first stage regression results for IV(II) have an interesting economic interpretation. Production by the United States multinationals in Canada is negatively related to Canadian taxes, and is positively related to United States taxes, which implies that corporate taxes result in a substitution of geographical location of production. The United States foreign control in Canada is positively related to United States-controlled production in other locations around the world. Lower tariffs on imports from Canada increase output by United States-controlled firms, except in customer sectors.[12] Tariff reductions against the rest of the world have the opposite effect.

The IV(I) estimate of α^{SUP} is 0.718 (t=3.25), and is close to the ordinary least squares (OLS) estimate. The Hausman test rejects endogeneity, and the Basmann test for overidentification suggests that lagged values of FDI are good instruments for current period FDI. The IV(II) estimate of α^{SUP} is 2.039 (t=4.16), and is substantially higher than the OLS estimate. We prefer the IV(I) results to IV(II) because the first stage R-squared are higher and because of more satisfying over-identification tests. Indeed, the Basmann test suggests that the first-stage explanatory variables in IV(II)—taxes and tariff rates—have independent effects on domestically-controlled plants' productivity growth. Also, while both IV estimates appear to suffer from an upward bias (a problem that commonly arises with grouped instruments), IV(II) suffers more so. The coefficient on FDI^{SUP} is positive in all specifications, and is highly significant in most of them. Most importantly, the Hausman test rejects endogeneity in all but one case. Therefore, in the discussion that follows, we will focus on the OLS estimates of the fixed effects model. Our goal now is to investigate the channels of technology transfer in greater detail, examining different aspects of the inter-industry linkages between foreign-controlled and domestically-controlled plants.

a. Strength of inter-industry linkages

As was earlier discussed, the relationship between industries is fairly localized. Therefore, one can expect that most of the technology transfer should come from closely related industries. Table 5 gives the estimates of equation (7) for changes in FDI^{SUP} and FDI^{CUST} in closely related industries. The major customer industries are defined as those that cumulatively *outsource* the first 50% of the industry's output of manufactured intermediate inputs. Similarly, the major supplier industries are defined as those that cumulatively *supply* the first 50% of the industry's manufactured intermediate inputs. The estimates in Table 5 show that positive and more sizeable effects for labour productivity growth come from FDI in closely related supplier industries: α^{SUP} goes from 0.625 (t=4.85) to 0.713 (t=5.20). FDI^{CUST} does not have a significant effect on productivity growth.

b. Technological contents of linkages

Since we expect spillovers to occur as a consequence of multinational plants having higher knowledge-based assets, the benefits from foreign direct investment may be higher for science-based or knowledge-based industries. For example, Keller (2004) notes that 80%

Table 6 Productivity growth, Canadian plants in science-based industries

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2	Over-identifying restrictions test		Hausman test	
	β	*t*	β	*t*	β	*t*		Test statistics	*Probability*	Test statistics	*Probability*
Industries (Plant FE)											
Science-based	-0.811	*-5.92*	1.686	*4.64*	2.332	*5.20*	0.67	...	...	...	...
Science-based suppliers	-0.416	*-4.76*	1.821	*9.41*	0.475	*1.98*	0.65	...	...	...	...
Industries (Plant FE, IV I[1])											
Science-based	-1.149	*-5.75*	1.658	*3.47*	2.103	*3.30*	0.66	26.85	*0.99*	6.96	*0.73*
Science-based suppliers	-0.384	*-2.59*	1.802	*5.58*	0.497	*1.09*	0.65	8.48	*0.79*	0.11	*1.00*
Industries (Plant FE, IV II[2])											
Science-based	-1.724	*-2.38*	3.274	*3.24*	2.088	*1.18*	0.66	1.09	*0.42*	3.84	*0.95*
Science-based suppliers	-1.310	*-1.45*	3.016	*5.71*	0.942	*0.39*	0.64	0.82	*0.33*	4.83	*0.90*

... not applicable
1. Instruments, IV I: lagged changes in FDI in own, supplier and customer sectors, their squares and their products (nine instruments).
2. Instruments, IV II: Canadian and U.S. tax rates, U.S. tariff against Canada, U.S. tariff against the rest of the world and sales by affiliates of U.S. corporations in the rest of the world (five instruments).

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Estimates are based upon equation (7). Number of observations: Science-based N=1,608, Science-based suppliers N= 7,194. List of science-based industries is in Table A4. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

of the aggregate R&D expenditures is done by three ISIC (International Standard Industrial Classification) 3-digit industries: 'Chemical Products', 'Machinery' and 'Transportation Equipment'. Therefore, foreign direct investment in these industries is more likely to contribute to technology transfer, because intermediates provided and used by these industries are likely to embody more technological advances than intermediates used by other manufacturing industries.

To see if foreign direct investment effects are stronger for science-based industries, we look separately at (a) domestically-controlled plants in science-based industries (Table 6), and (b) foreign direct investment in science-based industries (Table 7). In (a), the set of *recipients* of technological spillovers, and in (b), the set of *providers* of spillovers are restricted to science-based industries. Our list of science-based industries is shown in Appendix Table A4.[13]

Estimates in Table 6 are obtained for domestically-controlled plants who belong to science-based industries, as well as for domestically-controlled plants whose major supplier industries are science-based. Three conclusions follow from the estimates. First, the FDI^{SUP} effect is much larger and more significant for industries with science-based suppliers (α^{SUP} is 1.821, t=9.41), and for science-based industries (α^{SUP} is 1.686, t=4.64), compared to all plants (α^{SUP} is 0.625, t=4.85). Second, for plants in science-based industries, the effect of FDI in customer industries is also positive and significant: α^{CUST} is 2.332 (t=5.20). Finally, the negative effect of foreign competition in these high-end industries is also larger, in particular for domestically-controlled plants in science-based industries α^{CUST} is -0.811 (t=-5.92), compared to -0.128 (t=-2.33) for all plants. Therefore, for domestically-controlled plants in

Table 7 Productivity growth and United States foreign control in science-based industries

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{SUP}		ΔFDI^{CUST}		ΔFDI^{CUST}		R^2	Over-identifying restrictions test		Hausman test	
	β	*t*	β	*t*	β	*t*	β	*t*	β	*t*		Test statistics	*Probability*	Test statistics	*Probability*
Industries (Plant FE)															
All	-0.203	*-3.61*	1.178	*5.89*	0.256	*1.76*	1.030	*3.58*	-0.340	*-2.75*	0.65	...	...	...	...
Science-based suppliers	-0.413	*-4.69*	1.666	*6.82*	1.819	*7.15*	1.070	*2.65*	0.099	*0.31*	0.65	...	...	...	...
Industries (Plant FE, IV I[1])															
All	-0.232	*-1.46*	0.968	*0.61*	0.602	*0.21*	-0.314	*-0.08*	-0.555	*-0.32*	0.64	4.14	*0.61*	6.21	*0.91*
Science-based suppliers	-0.395	*-2.00*	1.925	*4.15*	3.939	*3.28*	-2.923	*-1.58*	2.947	*1.91*	0.63	4.00	*0. 59*	5.18	*0.95*
Industries (Plant FE, IV II[2])															
All	-0.902	*-2.00*	4.230	*3.37*	2.374	*3.49*	0.388	*0.14*	1.571	*1.15*	0.66	7.23	*0.94*	10.35	*0.58*
Science-based suppliers	-1.823	*-2.22*	2.751	*3.88*	3.349	*7.50*	3.755	*1.21*	1.914	*1.10*	0.63	3.41	*0.67*	15.73	*0.20*

... not applicable

1. Instruments, IV I: lagged changes in FDI in own, supplier and customer sectors, their squares and their products (nine instruments).
2. Instruments, IV II: Canadian and U.S. tax rates, U.S. tariff against Canada, U.S. tariff against the rest of the world, sales by affiliates of U.S. corporations in the rest of the world, and squares of tax rates and sales (eight instruments).

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Estimates are based upon equation (7). List of science-based industries is in Table A4. Industries with science-based suppliers are defined as industries who have a science-based industry among top three suppliers. Number of observations: science-based industries N=1,607; industries with science-based suppliers N=7,194. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

technology-intensive sectors, the effect of technology transfer through vertical linkages is larger, as we expected; but the negative effect of foreign competition is also stronger.

To isolate the effect of foreign control in science-based industries, we re-estimate equation (7) using the following decomposition:

$$FDI^{SUP}_{i,t}, Science\text{-}based = \sum_j d_j * FDI^{SUP}_{j,t}, \quad FDI^{CUST}_{i,t}, Science\text{-}based = \sum_j d_j * FDI^{CUST}_{j,t}$$

where d_j equals 1 if industry j is one of the science-based industries and equals 0 otherwise. The first row of Table 7 shows estimates for 'All' industries. The coefficients on $FDI^{SUP}_{i,t}, Science\text{-}based$ is 1.178 (t=5.89), while the coefficient on FDI in the rest of manufacturing is small and statistically insignificant. So, the positive effect from FDI in supplier sectors, estimated in Table 7, occurs mainly from FDI in science-based sectors of the economy. Interestingly, $FDI^{CUST}_{i,t}, Science\text{-}based$ is also positive and significant. Estimates for industries with science-based suppliers in Table 7 do not attribute the FDI effect to science-based industries only. The fact that for this industry grouping most suppliers are science-based would probably explain this finding.

The larger estimates of the productivity effects of FDI for the science-based industries—both for science-based customers and science-based suppliers—suggest that the amount of knowledge embedded into intermediate inputs is crucial for there to be productivity gains from linkages with foreign-controlled plants.

c. Plant purchases of intermediate inputs

We have shown that foreign direct investment in the supplier sector brings productivity benefits to domestically-controlled plants. We have also shown that these benefits come through foreign direct investment in closely related industries, in particular through foreign direct investment in the technology-intensive sectors of the economy and to domestically-controlled plants that utilize technology-intensive intermediates. We still want to further explore this finding by linking the productivity effects to characteristics of individual plants within industries. That is, the hypothesis of technology transfer through intermediate inputs assumes that multinational corporations produce *advanced specialized* intermediate inputs, and supply these inputs to host country plants. Hence, one might expect the productivity effects to be more pronounced for domestically-controlled plants that buy relatively more intermediates; and, in particular, for those plants that buy more technologically advanced intermediates.

Table 8a presents results for plants divided into three groups based on the ratio of purchases of intermediates to total shipments in 1989 (the ranking is done *within* industries). The average ratios are 0.63, 0.51 and 0.35 for plants with high, average and low purchases of intermediates, respectively. The estimate of supplier FDI effect is substantially higher for plants that outsource intermediates more intensively. For plants with high outsourcing ratios, α^{SUP} is 0.756 (t=3.45) compared to 0.380 (t=1.63) for plants with low outsourcing ratios. The same pattern is observed for plants in industries with science-based suppliers, except that the magnitude of the foreign suppliers' effect is much stronger. For plants with a high use of intermediates, α^{SUP} is 2.362 (t=7.11), while for plants with low use, α^{SUP} is 1.410 (t=4.10).

Tables 8a and 8b provide a key finding of the paper: *plants that purchase science-based intermediates gain from the presence of United States suppliers in Canada, and plants that use more intermediates, benefit more so.* (The same conclusion follows from the IV estimates from Table 8b.) Evaluated at the standard deviations of variables, for industries with science-based suppliers, own sector FDI decreases productivity growth by 0.37%, and FDI in supplier sectors increases it by 0.73%. This means that the beneficial effect from the presence of the United States-controlled suppliers in Canada offsets the negative effect of foreign competition on domestically-controlled producers.

Both FDI^{SUP} and FDI^{CUST} change over time as a result of changes in the inter-industry linkages and the relative shares of output of foreign-controlled firms in linked sectors. It is possible that the estimated effect on productivity arises as a result of a favourable change in linkages, rather than from an increase in FDI (for example, a technological change in industry

Table 8a Productivity growth, plants ranked by purchases of intermediate inputs

Explanatory variables		ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2
	Intermediate inputs-to-output ratio	β	*t*	β	*t*	β	*t*	
All industries (Plant FE)								
High	*0.63*	-0.271	*-2.95*	0.756	*3.45*	0.021	*0.11*	0.68
Medium	*0.51*	-0.072	*-0.80*	0.600	*2.82*	-0.093	*-0.48*	0.66
Low	*0.35*	-0.025	*-0.24*	0.380	*1.63*	-0.276	*-1.33*	0.66
Industries with science-based suppliers (Plant FE)								
High	*0.64*	-0.536	*-3.68*	2.362	*7.11*	0.371	*0.91*	0.67
Medium	*0.52*	-0.392	*-2.70*	1.488	*4.62*	0.846	*2.14*	0.61
Low	*0.36*	-0.233	*-1.44*	1.410	*4.10*	0.010	*0.21*	0.68

Table 8b Productivity growth, plants ranked by purchases of intermediate inputs

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2	Over-identifying restrictions test		Hausman test	
	β	*t*	β	*t*	β	*t*		Test statistics	*Probability*	Test statistics	*Probability*
All industries (Plant FE, IV I)[1]											
High	-0.340	*-2.46*	0.766	*2.08*	-0.234	*-0.58*	0.68	1.40	*0.16*	1.15	*1.00*
Medium	0.157	*1.04*	0.655	*1.76*	-0.807	*-2.01*	0.63	1.73	*0.21*	6.28	*0.79*
Low	-0.426	*-2.28*	0.759	*1.84*	-0.792	*-1.74*	0.64	3.47	*0.52*	9.88	*0.45*
Industries with science-based suppliers (Plant FE , IV I)[1]											
High	-0.632	*-2.52*	2.766	*5.00*	0.800	*1.04*	0.67	5.19	*0.73*	0.83	*1.00*
Medium	0.128	*0.51*	0.990	*1.75*	-0.576	*-0.76*	0.60	3.32	*0.50*	6.48	*0.77*
Low	-0.573	*-2.03*	1.353	*2.49*	1.039	*1.22*	0.68	3.07	*0.45*	2.34	*0.99*
All industries (Plant FE, IV II)[2]											
High	-0.751	*-1.91*	2.290	*4.11*	1.119	*0.93*	0.68	26.67	*0.99*	9.06	*0.53*
Medium	-0.279	*-0.73*	1.980	*3.58*	-1.722	*-1.49*	0.59	11.03	*0.95*	16.03	*0.10*
Low	-0.875	*-2.07*	1.620	*2.68*	0.070	*0.06*	0.65	3.27	*0.34*	7.69	*0.66*
Industries with science-based suppliers (Plant FE , IV II)[2]											
High	-2.190	*-2.37*	3.594	*5.20*	6.243	*2.65*	0.63	14.59	*0.98*	8.25	*0.60*
Medium	-1.462	*-1.81*	3.172	*4.68*	-1.389	*-0.61*	0.59	4.55	*0.53*	20.26	*0.03*
Low	-1.606	*-1.85*	2.455	*3.27*	2.839	*1.30*	0.68	2.05	*0.16*	2.42	*0.99*

1. Instruments, IV I: lagged changes in FDI in own, supplier and customer sectors, their squares and their products (nine instruments).
2. Instruments, IV II: Canadian and U.S. tax rates, U.S. tariff against Canada, U.S. tariff against the rest of the world and sales by affiliates of U.S. corporations in the rest of the world (five instruments).

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Estimates are based upon equation (7). Number of observations: All industries: high N=5,400, medium N=5508, low N=5,268. Science-based suppliers industries: high N=2,408, medium N=2,455, low N=2,331. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

i could lead to higher consumption of high-end intermediates and productivity improvements). To ensure that the positive effect of FDI^{SUP} on productivity occurs in part as a result of a change in FDI per se, we estimate equation (7) redefining (4) and (5) so that linkages are fixed at the level of the beginning of period t_0, and allowing FDI to change:

$$FDI_{i,t}^{CUST} = \sum_j CUST_{i,j,t_0} FDI_{j,t}^{OWN}, \quad FDI_{i,t}^{SUP} = \sum_j SUP_{i,j,t_0} FDI_{j,t} \qquad (4'), (5')$$

Table 9 Productivity growth, regional foreign control effects

Explanatory variables	ΔFDI^{OWN} local		ΔFDI^{OWN} not local		ΔFDI^{SUP} local		ΔFDI^{SUP} not local		ΔFDI^{CUST} local		ΔFDI^{CUST} not local		R^2
	β	t	β	t	β	t	β	t	β	t	β	t	
Industries (Plant FE)													
All	-0.142	*-2.49*	-0.112	*-1.92*	0.661	*4.91*	0.586	*4.32*	-0.111	*-0.90*	-0.113	*-0.87*	0.64
Science-based suppliers	-0.435	*-4.85*	-0.394	*-4.33*	1.825	*9.14*	1.809	*8.78*	0.460	*1.84*	0.488	*1.87*	0.65
Industries (Plant FE, IV I)[1]													
All	0.123	*0.13*	-0.289	*-0.38*	1.495	*1.85*	-0.920	*-0.87*	-0.355	*-0.54*	0.636	*0.47*	0.61
Science-based suppliers	0.763	*0.55*	-1.339	*-1.22*	1.444	*2.48*	-1.601	*-0.60*	-0.562	*-0.32*	2.756	*0.94*	0.47
Industries (Plant FE, IV II)[2]													
All	-1.603	*-2.38*	0.452	*0.46*	3.753	*4.54*	-1.030	*-0.68*	0.004	*0.00*	-1.385	*-0.93*	0.51
Science-based suppliers	-0.532	*-0.35*	-2.276	*1.45*	3.361	*4.27*	6.459	*1.87*	6.954	*1.12*	-1.828	*-0.40*	0.42

1. Instruments, IV I: lagged changes in FDI in own, supplier and customer sectors, their squares and their products (nine instruments).
2. Instruments, IV II: Canadian and U.S. tax rates, U.S. tariff against Canada, U.S. tariff against the rest of the world sales by affiliates of U.S. corporation in the rest of the world, and squares of tax rates and sales (eight instruments).

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Estimates are based on equation (7). Number of observations N=16,176. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects. Result of test for overidentifying restrictions for IV estimations are (in the order as presented in the tables above): Basmann Statistics (Prob.): 0.60 (0.03), 1.18 (0.12), 0.35 (0.87), 0.68 (0.29); Hausmann Test (Prob.): 7.4 (0.88), 2.9 (0.99), 21.5 (0.06), 6.0 (0.95).
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.

Source: Statistics Canada.

Table A5 shows estimates for industries with science-based suppliers, overall, and for plants ranked by their use of intermediate inputs. By and large, there is little change in the α^{SUP} estimates from Tables 6 and 8. It can therefore be suggested that the estimated FDI effects, to a large extent, result from changes in foreign production.

d. Geographical location of suppliers

From a policy point of view, it is useful to test whether the benefits from foreign direct investment are local or economy-wide. We therefore again re-estimate equation (7), this time distinguishing between local foreign direct investment (in the economic region of domestically-controlled plants), and foreign direct investment outside the economic region. OLS estimates in Table 9 give somewhat more weight to local foreign direct investment in supplier sectors, but the difference is small. The IV estimates suggest that regional FDI^{SUP} is more important for productivity growth, however endogeneity is once more rejected.

e. What underlies the estimated foreign direct investment effects on productivity growth?

The central finding of the paper is that foreign direct investment in supplier sectors increases the productivity growth of domestically-controlled plants. This effect can arise from different sources. Estimates in Table 10 show that an increase in output by the United States-controlled suppliers in Canada is associated with a growth in the value of shipments by domestically-

Table 10 Effects of foreign control on selected plant variables

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2
	β	t	β	t	β	t	
All industries (Plant FE)							
(1) Value of shipments	-0.327	*-3.65*	0.447	*2.12*	-0.308	*-1.68*	0.12
(2) Employment	-0.167	*-1.82*	-0.416	*-1.92*	0.097	*0.51*	0.09
(3) Intermediates per worker	-0.122	*-1.32*	1.145	*5.23*	-0.207	*-1.09*	0.02
(4) Material inputs per unit of value added	0.108	*0.92*	0.735	*2.68*	0.073	*0.31*	0.01
(5) Wage per worker	-0.179	*-4.05*	0.406	*3.90*	-0.276	*-3.04*	0.01
Industries with science-based suppliers (Plant FE)							
(6) Value of shipments	-0.488	*-3.88*	1.206	*3.97*	-0.759	*-2.09*	0.13
(7) Employment	-0.081	*-0.63*	-1.178	*-3.81*	-0.169	*-0.45*	0.09
(8) Intermediates per worker	-0.551	*-4.25*	2.907	*9.26*	-0.514	*-1.38*	0.05
(9) Material inputs per unit of value added	-0.130	*-0.78*	0.990	*2.47*	-0.487	*-1.02*	0.01
(10) Wage per worker	-0.352	*-5.70*	1.241	*8.30*	-0.322	*-1.81*	0.02

Notes: Annual changes, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Estimates are based on equation (7). Number of observations: all industries N=16,176; industries with science-based suppliers N=7,194. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FE=fixed effects. FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

controlled plants, as well as in higher wages. However, an increase in FDI^{SUP} is also associated with a fall in employment in domestically-controlled plants. There is also a large and highly significant increase in the use of intermediates per worker (i.e., higher labour utilization rates), and a modest increase in the use of purchased materials per unit of value added. All of these effects are more pronounced for industries with science-based suppliers. So, our findings are consistent with skill and/or input upgrading caused by the presence of foreign suppliers. For example, an increase in supplies of advanced intermediates produced by foreign-controlled firms may substitute for some low-skilled labour, therefore causing a fall in employment as well as an increase in average wage and utilization of high-skilled labour. Since we do not observe changes in plant machinery and equipment, we can only speculate that this higher labour utilization rate is a consequence of technology transfer from foreign-controlled plants, who supply advanced manufacturing technologies and complementary intermediate inputs to domestically-controlled plants.

Re-estimates of equation (7) with a log change in output as an independent variable (Table 10, row 1) show that FDI^{OWN} has a negative effect on output: α^{OWN} is -0.327 (t=-3.65). Similar to the findings by Aitkin and Harrison (1999) for Venezuela, we find that an increase in industry share of foreign output in Canada reduces the output of domestically-controlled plants. (The corresponding estimate obtained for Venezuela was -0.206). Also, FDI^{OWN} has negative effects on wages paid in domestically-controlled plants (α^{OWN} is -0.179 t=-4.05), and to a lesser extent on employment (α^{OWN} is -0.167 t=-1.82). Therefore, the evidence is consistent either with a market-stealing effect of foreign-controlled production on domestically-controlled plants, or with skill or value degrading of output produced by domestically-controlled plants in sectors experiencing expansion of foreign-controlled production. Note that these negative effects are not particularly large in economic terms.

Changes in FDI in customer sectors have almost no significant effects on domestically-controlled plants. The only notable effects of FDI^{CUST} are a reduction in output by domestic producers, and a reduction in wages paid by domestically-controlled plants. The absence of benefits from FDI in the customer sector may be interpreted as a lack of demand from foreign-controlled buyers for domestically produced intermediates.

Endnotes

7. Strong mean-reversion in productivity growth is a common finding by researchers.
8. The insignificance of the coefficient on capital stock per worker can be explained by two factors. First, the equation already controls for plant-level fixed effects in productivity growth. Second, by construction, this variable includes the capital stock of foreign-controlled plants in the own industry of domestic plants; and the presence of foreign producers is found to be negatively correlated with productivity growth of domestically-controlled plants.
9. Baldwin and Gu (2005) who used the similar data but different estimation methods got the estimate of the own sector FDI effect to be -0.060 (t=-2.08).
10. Canadian tax data come from CANSIM of Statistics Canada and United States tax data come from the Bureau of Economic Analysis. Both tax data series were converted to roughly a SIC 2-digit level of aggregation.
11. United States FDI in the rest of the world was constructed using the data from the Bureau of Economic Analysis on activities of United States-controlled multinational corporations.
12. To understand the effect, one may think of the following example where the own sector is auto parts. A fall in the United States tariff against Canada increases the output of multinationals in the auto parts sector, and in sectors that supply to auto parts. However, production by foreign-controlled firms in the final goods sector—cars in this example—falls.
13. The science-based industries are defined according to the list developed by Statistics Canada. Most of the science-based industries fall into three categories: producers of industrial machinery, producers of electronic equipment and producers of chemicals.

Chapter 6. Conclusion

This paper uses data on domestically-controlled and the United States-controlled manufacturing plants located in Canada to test whether there are benefits to domestically-controlled plants from inward foreign direct investment. We distinguish between own sector foreign control, and foreign control in sectors that supply or consume intermediate inputs. We find that labour productivity growth in domestically-controlled plants is positively related to increases in foreign control in supplier sectors. In particular, an increase in supplier foreign control in science-based industries is positively associated with productivity growth within domestically-controlled plants. This is consistent with the hypothesis of technology transfer through vertical linkages between domestically-controlled and foreign-controlled plants. On the other hand, we find that foreign control in the customer sector has no effect on the productivity growth of domestically-controlled plants and is negatively associated with their output growth.

The absence of customer foreign control effects in Canada seemingly contradicts findings by Blalock and Gertler (2004) for Indonesia and Smarzynska Javorcik (2004) for Lithuania. However several facts might help explain this difference. Foremost, is Canada's close geographical proximity with the United States, the major source country of foreign direct investment. This close geographical proximity and falling trade costs as a result of the FTA (Canada-U.S. Free Trade Agreement) and NAFTA (North American Free Trade Agreement) may have induced American producers in Canada to outsource more intermediates from the United States or Mexico, rather than from Canadian suppliers. Several empirical observations point to the possibility that domestically-controlled plants in Canada may be replaced in supply chains by alternative suppliers of intermediate inputs. For example, Hanson, Mataloni and Slaughter (2001) document a high growth in the share of imported intermediate inputs by Canadian affiliates of United States companies. For manufacturing as a whole, the ratio of imported intermediates to affiliate sales went up from 21.6% to 36.7% over the period from 1982 to 1994. This increase in imports of intermediates by affiliates of United States corporations may substitute for output from local suppliers. In this case, an increase in United States foreign direct investment in the customer sector will have no effect on the productivity of domestically-controlled producers.

The policy implications of this research are numerous. If foreign direct investment contributes to technological upgrading by domestically-controlled plants, then the presence of inward foreign direct investment is crucial for Canada's long-run productivity growth outlook. Future research should be aimed at further refining the linkage measures to better analyze

the specific channels through which foreign direct investment leads to technological upgrading by domestically-controlled plants. Such research would also improve our understanding of the opportunities for recipient countries to leverage further benefits from the international technology transfers associated with foreign direct investment.

Appendix

Table A1 Alternative specifications

Specification	Omit industry capital stock		Omit industry capital stock		Omit industry capital stock, imports and exports		Omit industry capital stock, imports and exports	
	All industries		Industries with science-based suppliers		All industries		Industries with science-based suppliers	
	β	t	β	t	β	t	β	t
ΔFDI^{OWN}	-0.141	*-2.59*	-0.441	*-5.40*	-0.156	*-2.89*	-0.490	*-6.26*
ΔFDI^{SUP}	0.646	*5.06*	1.842	*9.63*	0.651	*5.13*	1.908	*10.04*
ΔFDI^{CUST}	-0.073	*-0.65*	0.531	*2.33*	-0.076	*-0.69*	0.594	*2.63*
ΔImports	-0.012	*-1.13*	-0.034	*-1.82*	...	...	...	...
ΔExports	0.029	*3.24*	0.081	*4.76*	...	...	...	...
Adjusted R^2	0.64	...	0.65	...	0.64	...	0.65	...

... not applicable
Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

Table A2 First stage regressions, IV (I)

Dependent variable	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Lagged ΔFDI^{OWN}	-0.584	*-50.17*	0.030	*6.11*	0.025	*4.53*
Lagged ΔFDI^{OWN} 2	-3.883	*-6.17*	-0.259	*-0.98*	-1.335	*-4.33*
Lagged ΔFDI^{SUP}	0.451	*16.32*	-0.612	*-52.76*	-0.008	*-0.63*
Lagged ΔFDI^{SUP} 2	-1.205	*-0.14*	-6.566	*-1.77*	2.543	*0.59*
Lagged ΔFDI^{CUST}	0.079	*2.95*	-0.013	*-1.18*	-0.529	*-40.70*
Lagged ΔFDI^{CUST} 2	-6.879	*-1.66*	-10.421	*-5.97*	7.390	*3.63*
Lagged ΔFDI^{OWN} *Lagged ΔFDI^{SUP}	-11.003	*-2.55*	1.206	*0.67*	-7.971	*-3.77*
Lagged ΔFDI^{OWN} *Lagged ΔFDI^{CUST}	6.964	*1.84*	-2.582	*-1.62*	-1.005	*-0.54*
Lagged ΔFDI^{SUP} *Lagged ΔFDI^{CUST}	-67.73	*-6.95*	-22.109	*-5.40*	-30.480	*-6.39*
Adjusted R^2	0.23	...	0.42	...	0.24	...

... not applicable
Notes: FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

Table A3 First stage regressions, IV (II)

Dependent variable	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Canadian tax	-0.086	*-19.34*	-0.027	*-15.22*	-0.004	*-1.99*
U.S. tax	0.011	*15.03*	-0.001	*-5.32*	0.003	*8.85*
U.S. FDI in the rest of the world	0.001	*12.08*	0.001	*23.16*	0.0001	*5.02*
U.S.-Canada tariff	0.014	*3.05*	0.030	*16.76*	-0.014	*-7.02*
U.S. tariff against the rest of the world	-0.023	*-6.01*	-0.033	*-21.14*	0.011	*6.23*
Adjusted R^2	0.14	...	0.36	...	0.16	...

... not applicable
Notes: FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

Table A4 Science-based industries

N	SIC 2-digit	SIC 2-digit description	Input-Output	Input-Output description
1	31	Machinery	101	Agricultural implement
2	31	Machinery	102	Commercial refrigerator and air conditioning equipment
3	31	Machinery	103	Compressor, pump, turbine and other equipment
4	31	Machinery	104	Construction, mining and handling machinery
5	31	Machinery	105	Sawmill, woodwork and other machinery and equipment
6	32	Transportation equipment	106	Aircraft and aircraft parts
7	33	Electrical and electronic products	124	Record player, radio and television receiver
8	33	Electrical and electronic products	125	Telecommunication equipment
9	33	Electrical and electronic products	126	Electronic parts and components
10	33	Electrical and electronic products	128	Electronic computing and peripheral equipment
11	33	Electrical and electronic products	129	Electronic and other office, store and bus. mach.
12	33	Electrical and electronic products	130	Electrical transformer
13	33	Electrical and electronic products	131	Switchgear, protect and other electronic equipment
14	36	Refined petroleum and coal products	143	Refined petroleum products
15	36	Refined petroleum and coal products	144	Other petroleum and coal products
16	37	Chemical and chemical products	145	Industrial inorganic chemical
17	37	Chemical and chemical products	146	Industrial organic chemical, not earlier specified
18	37	Chemical and chemical products	147	Agricultural chemical
19	37	Chemical and chemical products	148	Plastic and synthetic resin
20	37	Chemical and chemical products	149	Pharmaceutical and medicine
21	37	Chemical and chemical products	153	Other chemical products
22	39	Other manufacturing	154	Indicating, recording and controlling equipment
23	39	Other manufacturing	155	Other scientific and professional equipment

Note: SIC=Standard Industrial Classification.
Source: Statistics Canada.

Table A5 Alternative specifications: fixed linkages, industries with science-based suppliers

Explanatory variables	ΔFDI^{OWN}		ΔFDI^{SUP}		ΔFDI^{CUST}		R^2
	β	t	β	t	β	t	
Dependent variables:							
Δ Labour productivity							
All domestic plants in science-based industries	-0.221	*-2.44*	1.920	*7.39*	-0.729	*-1.71*	0.65
Plants ranked by purchases of intermediates:							
High	-0.298	*-1.94*	3.081	*6.87*	-2.040	*-2.76*	0.67
Medium	-0.236	*-1.57*	1.179	*2.73*	0.656	*0.94*	0.61
Low	-0.113	*-0.69*	1.374	*2.97*	-0.670	*-0.89*	0.68
Intermediates per worker	-0.516	*-3.62*	3.103	*7.55*	-0.991	*-1.41*	0.04
Material inputs per unit of value added	-0.153	*-0.84*	0.777	*1.48*	-0.105	*-0.12*	0.01
Value of shipments	-0.477	*-3.46*	1.112	*2.80*	-0.853	*-1.26*	0.13
Wage per worker	-0.277	*-4.09*	1.612	*8.27*	-1.389	*-4.18*	0.02
Employment	-0.109	*-0.78*	-1.372	*-3.39*	0.178	*0.26*	0.09

Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants, pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Same plant and industry controls are used in all productivity growth regressions (see Table 4). All regressions control for plant and year fixed effects.
FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

Table A6 Alternative IV strategies

Specification	Endogenize exports and imports, IV I			Endogenize exports and imports, IV I			Endogenize exports and imports, IV II			Endogenize exports and imports, IV II		
	All industries			Industries with science-based suppliers			All industries			Industries with science-based suppliers		
	β	t	First stage R^2	β	t	First stage R^2	β	t	First stage R^2	β	t	First stage R^2
ΔFDI^{OWN}	-0.044	*-0.15*	0.23	-0.359	*-2.26*	0.28	0.061	*1.26*	0.14	-1.189	*-1.68*	0.20
ΔFDI^{SUP}	0.562	*1.65*	0.41	1.680	*4.60*	0.34	1.647	*2.09*	0.36	2.122	*2.10*	0.33
ΔFDI^{CUST}	-0.559	*-1.59*	0.23	0.128	*0.24*	0.20	-0.283	*-0.27*	0.15	2.459	*1.85*	0.11
Δ Imports	-0.071	*-0.72*	0.25	-0.017	*-0.87*	0.20	0.061	*1.26*	0.25	0.005	*0.10*	0.17
Δ Exports	-0.014	*-0.14*	0.13	0.134	*2.55*	0.03	0.027	*0.28*	0.15	0.080	*1.42*	0.10
Adjusted R^2	0.64	...	...	0.64	...	...	0.64	...	...	0.64	...	...
	Test statistics	Probability		Test statistics	Probability		Test statistics	Probability		Test statistics	Probability	
Overidentifying restrictions test	3.81		*0.85*	10.44		*0.98*	...		...	...		...
Hausman test	6.31	*0.79*	3.31	*0.97*	29.7	*0.00*	14.04	*0.17*				

... not applicable
Notes: Dependent variable: annual change in labour productivity in Canadian-controlled plants. Pooled panel of plants over the 1981 to 1989 and 1989 to 1997 periods. Same plant and industry controls are used in all productivity growth regressions. All regressions control for plant and year fixed effects.
FDI=foreign direct investment. SUP=supplier. CUST=customer.
Source: Statistics Canada.

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